

Comparison of Airway Assessment by Pocus and Clinical Parameters for Prediction of Difficult Laryngoscopy and Intubation Corroborated By Cormack Lehane Score

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Received: 01-07-2025 / Revised: 15-08-2025 / Accepted: 21-09-2025

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Conflict of interest: Nil

Abstract

Background: Early 21st century saw an increase in the use of POCUS in emergency and critical care. Incidence of difficult laryngoscopy and tracheal intubation still ranges between 1.5%–13%. Inability to predict difficult airways is probably due to high inter-observer variability and low predictability of commonly used airway assessment screening tests. Recognition of the difficult airway is a critical and most important element in anaesthesiology practice. Preoperative airway evaluation using clinical predictors is a mandatory step for the anaesthesiologist to predict difficult laryngoscopy.

Methods: After ethical committee clearance all patients were randomly selected for this prospective interventional study. Conventional airway assessment was done by assessment of MPS and HMDR. Ultrasound airway assessment (DSHB, DSEM, E-VC) was done and pre-operative informed consent was taken. Direct laryngoscopy was done and CL grading and any difficult intubation was noted.

Results: Utilising receiver operating curves, a correlation was computed to assess the relation between USG-guided DSHB and DSEM, E-VC and HMDR with CL grading. There was moderate positive correlation of DSHB and DSEM with CL grading. The E-VC parameter had strong positive relationship, whereas negative correlation was observed with HMDR.

Conclusion: The strong positive correlation of E-VC and moderate negative correlation of HMDR with CL grading makes these ultrasound parameters reliable predictors for difficult laryngoscopy.

Keywords: Difficult Airway, Airway Ultrasound, Ultrasound, difficult laryngoscopy.

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Introduction

Traditionally, ultrasound has been predominantly utilized for abdominal, cardiac, and obstetric imaging. During the 1980s and 1990s, several studies explored its potential role in head and neck imaging; however, it was not widely adopted for airway assessment at that time. With the advent and growth of Point-of-Care Ultrasound (POCUS) in the early 2000s, its use expanded significantly in emergency and critical care settings.

The 2010s marked a rapid increase in publications and research focusing on airway assessment using ultrasound. Airway-related morbidity, particularly resulting from the inability to anticipate a difficult airway, continues to be a major concern for anaesthesiologists. [2] The reported incidence of difficult laryngoscopy and tracheal intubation

ranges between 1.5% and 13%. This inability to accurately predict a difficult airway is likely due to the high inter-observer variability and low predictive value of the commonly employed clinical airway assessment tests. [3,4]

Recognition of a potentially difficult airway remains a critical element of safe anaesthetic practice. Preoperative airway evaluation using clinical predictors is a mandatory step to anticipate challenges during laryngoscopy and intubation. [1] However, a meta-analysis by Lundstrom et al. [5] highlighted the low predictability and limited reliability of traditional clinical indices in identifying difficult airways.

In a study by Takenaka et al. [6], the Hyo-Mental Distance Ratio (HMDR)—defined as the ratio of the hyomental distance in full head extension to that in the neutral position—was shown to correlate with the extension capacity of the occipito-atlanto-axial complex, a key determinant of upper airway alignment during laryngoscopy.

Recent studies [8,9] have demonstrated that ultrasound-based measurements—such as the depth of the pre-epiglottic space (Pre-E) and the distance from the epiglottis to the midpoint between the vocal cords (E-VC)—correlate well with Cormack–Lehane (CL) grading, thereby offering a potential tool for predicting difficult laryngoscopy.

Thus, there is a compelling need for reliable, objective, and reproducible methods of airway assessment prior to laryngoscopy. In recent years, mounting evidence [10,11] supports the usefulness of ultrasound-guided preoperative predictors for identifying difficult airways. Various sonographically derived parameters have been found to correlate with difficult laryngoscopy. However, these encouraging results are limited by factors such as ethnic variability, small sample sizes, and the lack of standardized ultrasound scanning protocols.

Therefore, the present study was undertaken to evaluate the feasibility and reliability of point-of-

care ultrasound (POCUS) in assessing the airway, utilizing soft tissue neck measurements—specifically at the level of the hyoid bone (DSHB), thyrohyoid membrane (DSEM), and the pre-epiglottic space (Pre-E) or E-VC distance—for predicting difficult intubation. These parameters were also compared with conventional preoperative airway assessment methods.

Conventional Airway Assessment

Mallampati Score: The Mallampati score (or Mallampati classification), named after Indian anaesthesiologist Dr. Seshagiri Mallampati, is a simple clinical test used to predict the ease of endotracheal intubation. It assesses the visibility of oropharyngeal structures with the mouth open and tongue protruded, serving as an indirect measure of tongue size relative to the oral cavity.

Hyo-Mental Distance Ratio (HMDR): The Hyo-Mental Distance Ratio (HMDR) is defined as the ratio of the hyomental distance in full head extension (HMD_e) to that in the neutral position (HMD_n). It serves as an indicator of the head and neck extension capability, which is crucial for aligning the oral, pharyngeal, and laryngeal axes during laryngoscopy. The Thyromental Distance (TMD), measured at full head extension, is also used as a conventional clinical predictor of difficult intubation.

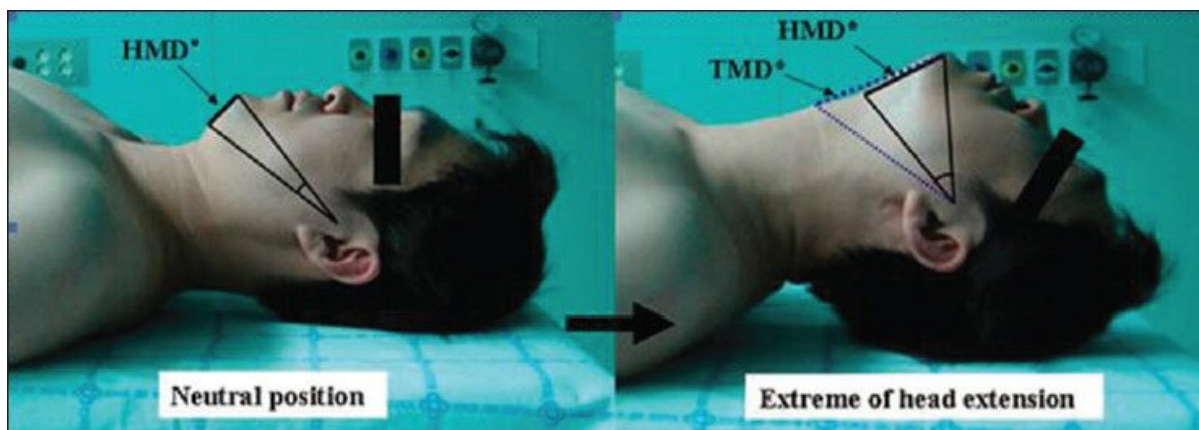


Figure 1:

It is calculated by dividing the hyomental distance at the extreme of head extension (HMD_e) by the hyomental distance in the neutral position (HMD_n).

A lower HMDR value, particularly below 1.2, has been shown to correlate with an increased risk of difficult intubation.

Ultrasound Airway Assessment:

- E-VC: distance from epiglottis to midway between vocal cords.
- DSHB: distance from the skin to hyoid bone.
- DSEM: distance from the skin to epiglottis at the level of thyrohyoid membrane.

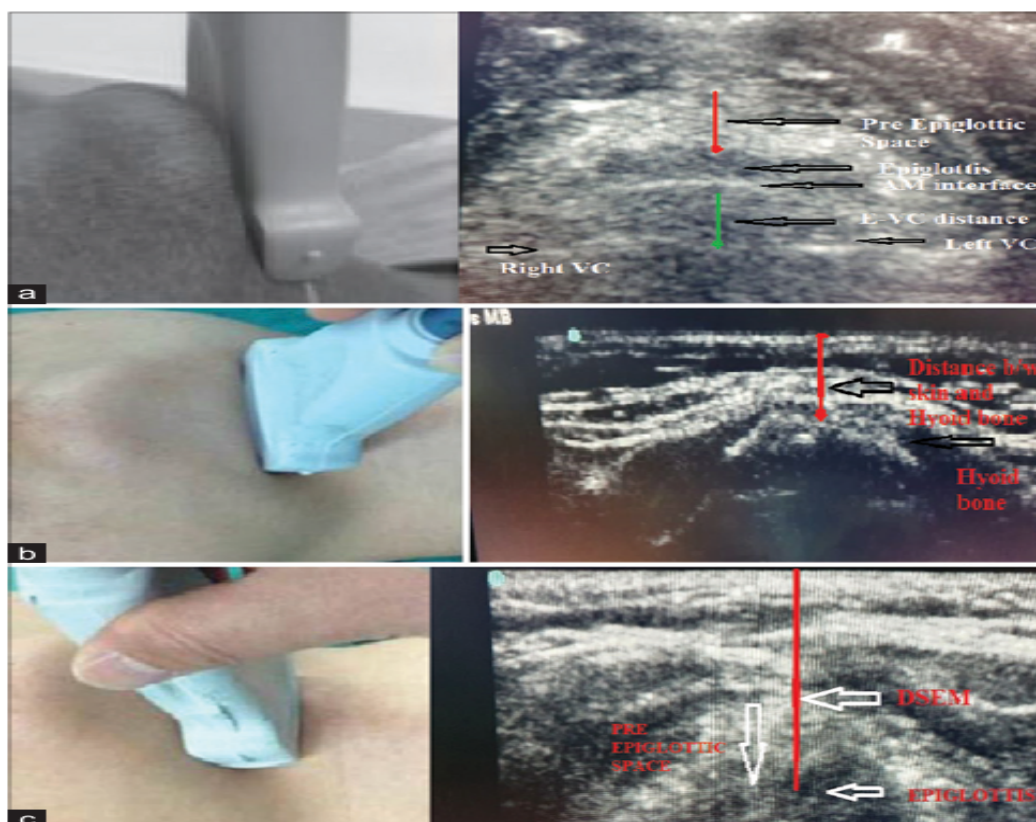


Figure 2:

(a) Figure representing position of USG probe and corresponding image. AM interface: air mucosal interface. E-VC: distance from epiglottis to midway between vocal cords. VC: vocal cords. (b) Depicting the position of USG probe and corresponding image on screen.

DSHB: distance from the skin to hyoid bone. (c) Depiction of USG probe position and corresponding image on USG screen. DSEM: distance from the skin to epiglottis at the level of thyrohyoid membrane.

Cormack Lehane Grading: The Cormack–Lehane classification system is a method used in anaesthesiology to categorize the view obtained during direct laryngoscopy, primarily assessing the visibility of the glottis and surrounding laryngeal structures. Introduced in 1984 by British anaesthetists R.S. Cormack and J. Lehane, this system aids in predicting the difficulty of tracheal intubation. In 1998, a modified version subdivided Grade 2 to enhance its predictive accuracy.

Table 1:

Grade	Description
I	Full view of the Glottis
IIa	Partial view of the Glottis
IIb	Only the posterior extremity of the glottis or only the arytenoid cartilages are visible.
III	Only the epiglottis is visible; the glottis is not seen.
IV	Neither the glottis nor the epiglottis is visible.

Materials and Methods

This was prospective interventional study performed in KPC Medical College & Hospital, Jadavpur from September 2024 to April 2025 after getting approval from the Institutional Ethical Committee and informed consent was taken from every patient enrolled in the study. 180 patients of ASA I and II belonging to age group 18 to 60 years planned for Laparoscopic Surgery were included.

The exclusion criteria included the following: Age less than 18 years and more than 60 years, known allergy to anaesthetic agents, history of substance abuse and current opioid use, pregnancy.

Method of randomization: Patients who fulfilled the inclusion criteria were included in the study and were examined for airway assessment in pre-anaesthesia clinic.

Study technique: The routine airway assessment including modified Mallampati scoring, hyomental distance ratio was done during the pre-anaesthetic assessment. The patients not meeting inclusion criteria were excluded from the study and the enrolled patients underwent sonographic assessment of airway by the anaesthesiologist during pre-anaesthetic checkup. In the preoperative holding area, with the patients lying supine and active maximal head-tilt/chin lift, the sonographic assessment was done. The high-frequency linear probe (6–13 Hz) utilising (SonoSite SII) was placed in the submandibular area in the midline. Without changing the position of the probe, the linear array of the US probe was slid in the transverse planes from cephalad to caudal, until simultaneous visualisation of the epiglottis was observed on the screen. Thereafter, following measurements were obtained with the oblique-transverse US view of the airway Pre-E. Then by changing head and neck to neutral position, thickness of anterior neck soft tissue were obtained with the transverse view at the following levels: (1) At the level of hyoid bone, that is, the minimal distance from the hyoid bone to the skin (DSHB) (2) at the level of the thyrohyoid membrane, that is, the distance from skin to epiglottis midway between the hyoid bone and thyroid cartilage (DSEM).

The patients were then taken to the operating room and the standard general anaesthesia procedure was performed as per the discretion of the attending anaesthesiologist and as per standard of care. General anaesthesia was induced and the trachea intubated by a senior anaesthesiologist with >5 years of experience post-qualification who was blinded to the findings of preoperative ultrasonographic airway assessment.

Direct laryngoscopy was performed using a Macintosh blade, and Cormack-Lehane (CL) grade noted without external laryngeal manipulation. The CL classification was as follows:[9] Grade 1: visualisation of the entire laryngeal aperture; Grade

2: visualisation of parts of the laryngeal aperture or the arytenoids; Grade 3: visualisation of only the epiglottis; Grade 4: visualisation of only the soft palate. The laryngoscopy was classified as easy (CL Grade 1 and 2) or difficult (CL Grade 3 and 4). The trachea was intubated with appropriate sized endotracheal tube and anaesthesia was maintained. The number of attempts at intubation, need for alternative difficult intubation approaches, or inability to secure the airway was also noted.

Sample size: The sample size was calculated according to the study by Rana et al.,[6] who found the incidence of difficult intubation to be 12.5%. Using Fisher's formula

$$[n = t^2 \times P(1 - P)/m^2 \text{ where } n = \text{required sample size; } t = \text{confidence level at 95\% (standard value of 1.96); } P = 0.125; m = \text{margin of error at 5\% (standard value 0.05)}].$$
 The sample size was calculated to be 168. We enrolled 200 patients, to allow for probable dropouts.

The data was entered in MS Excel and SPSS ver.29 software was used for analysis. The results were presented as mean $\pm$ standard deviation [SD] for each parameter for continuous data. The Chi-square test was used to determine the statistical difference between the easy and difficult laryngoscopies. The predictive value of the tests was assessed by calculating the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). To assess the optimal cutoff scores, receiver operating characteristic (ROC) graphs were plotted and the area under the curve (AUC) was calculated to assess the prognostic accuracy. A total of 180 eligible patients (88 females, 92 males) scheduled for elective surgery under general anaesthesia requiring endotracheal intubation were included in this study, out of which 26 patients (12.5%) were categorised as difficult laryngoscopy (CL grade 3 and 4). The demographic profile including age, gender were comparable in the easy and difficult laryngoscopy group [Table 1], whereas significant difference was observed between the weight and BMI with difficult airway.

Table 2:

Descriptives	CL Grading	Age	Weight	Height	BMI
N	4	6	6	6	6
	3	20	20	20	20
	2	80	80	80	80
	1	74	74	74	74
Mean	4	42.3	63.2	162	24.2
	3	41.8	60.5	159	23.8
	2	42	51.4	157	20.9
	1	42.1	51.4	158	20.7
Median	4	42.5	62.5	161	24
	3	42	59.5	160	23.9
	2	42	51	158	20.6
	1	42	51	157	20.3
Standard Deviation	4	2.58	2.48	7.19	1.59
	3	5.45	3.69	6.38	1.64
	2	4.65	2.43	7.04	1.51
	1	4.52	2.46	5.79	1.31

The weight was significantly higher in the patients belonging to CL grade 3, 4 (mean $\pm$ SD: 60.5 $\pm$ 3.69 and 63.2 $\pm$ 2.48) kgs as compared to CL grade 1, 2 (51.4 $\pm$ 2.46, 51.4 $\pm$ 2.43). The BMI was mean $\pm$ SD: 20.7 $\pm$ 1.51, 20.9 $\pm$ 1.51 in CL grade in 1, 2 in comparison to CL grade 3, 4 (mean $\pm$ SD: 23.8 $\pm$ 1.64 and 24.2 $\pm$ 1.59) [Table 1].

It was observed that 74 patients (29%) had CL Grade 1, and 80 patients had CL Grade 2 (58.5%), 20 patients had CL Grade 3 (11%), 6 patients belonged to CL grade 4 (1.5%). Therefore, the incidence of easy laryngoscopy was 87.5% and difficult 12.5%. In the study, 6 patients belonging to CL 4 required either more than a single attempt or additional equipment to achieve endotracheal intubation.

The distribution of CL grade as predicted by USG measured HMDR was (mean $\pm$ SD: 1.12 $\pm$ 0.0384, 1.11 $\pm$ 0.0205) for CL Grades 1 and 2, respectively, and HMDR 1.09 $\pm$ 0.0099 and 1.04 $\pm$ 0.0136 for CL Grade 3 and 4. The DSHB measured distribution was (mean $\pm$ SD: 0.852 $\pm$ 0.0985 and

0.875 $\pm$ 0.0918) cm for CL grade 1 and 2), while the measurement was 0.98 $\pm$ 0.0191 and 1.15 $\pm$ 0.0128 cm, respectively, for CL grade 3 and 4.

The distribution of CL grade as predicted by USG measured DSEM was (mean $\pm$ SD: 1.44 $\pm$ 0.173, 1.45 $\pm$ 0.174) cm for CL grades 1 and 2, respectively, and 1.94 $\pm$ 0.191 and 1.96 $\pm$ 0.17 for CL grade 3 and 4.

The values of Pre-E/E-VC ratio were (mean $\pm$ SD: 1.24 $\pm$ 0.223 and 1.55 $\pm$ 0.125) for CL grade 1, 2, respectively, and 1.92 $\pm$ 0.146, 2.29 $\pm$ 0.234 corresponded to CL grade 3 and 4. A correlation was computed to assess the relation between USG-guided DSHB and DSEM, Pre E/E-VC and HMDR with CL grading. There was moderate positive correlation of DSHB ($r = 0.509$, $P = <0.001$), respectively, whereas DSEM had strong positive linear correlation with CL grading ($r = 0.565$, $P = <0.001$). The Pre-E/E-VC parameter had strong positive relationship ($r = 0.833$, $P = <0.001$), whereas negative correlation was observed with HMDR ($r = -0.482$, $P = <0.001$) [Table 1].

Table 3:

	R	CI(LOWER)	CI(UPPER)	AUC	P
BMI	0.509	0.392	0.610	0.501	<0.001
MPS	0.258	0.117	0.390	0.254	<0.001
HMDR	-0.482	-0.587	-0.361	0.474	<0.001
DSHB	0.509	0.392	0.610	0.501	<0.001
DSEM	0.565	0.456	0.657	0.557	<0.001
PRE-E	0.833	0.782	0.873	0.828	<0.001

Utilising receiver operating curves (Fig. 1), the cutoff value of HMDR for predicting difficult laryngoscopy came out to be ≥ 1.031 with sensitivity of 96.15% and specificity of 0%. The NPV of HMDR was 0% and PPV 13.97%. The AUC for HMDR was 0.474 (95% CI = 0.686–0.838), therefore the accuracy of this is fair [Table

1], whereas Pre-E/E-VC had AUC of 0.871 (95% CI = 0.820–0.923) depicting good predictability in relation to CL grading. The cutoff value for Pre-E/E-VC was ≥ 1.785 with sensitivity of 82.8% and specificity of 83.8% for predicting difficult airway. The NPV of Pre-E/E-VC was 92.25% with PPV 67.61% ($P = 0.00$), whereas the cutoff value

of DSHB for predicting difficult laryngoscopy came out to be ≥ 0.99 with sensitivity of 48% and

specificity of 82%. The NPV of DSHB was 79.59% and PPV 52.83% [Table 1].

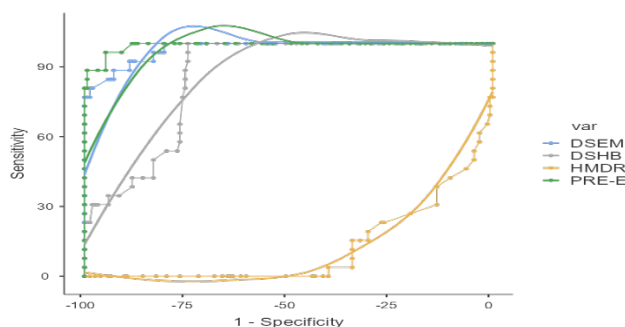


Figure 3:

Limitations- A larger sample size could have potentially yielded more robust and generalizable results. Also, if we could have taken neck circumference as a parameter, it could have yielded more accurate results.

Conclusion: We conclude that POCUS should be incorporated in preanaesthetic evaluation of airway by virtue of its better accuracy and correlation in predicting CL grading. The good predictive value of USG measured parameters, that is, Pre-E, DSEM, and HMDR ensure reliability of these variables in detecting difficult laryngoscopy.

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